April 5, 2021

To: Bureau of Industry and Security
Office of Technology Evaluation
U.S. Department of Commerce

From: Ann M. Carney Nelson
Chief Operating Officer
Inpria Corporation

Re: Inpria Corporation Comments in response to "Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain
Docket No. 21031909952

To whom it may concern:

Thank you for this opportunity to provide our comments and perspective. I would like to preface these comments with some of my own professional background. For the past 12 years I have been the Chief Operating Officer at Inpria Corporation. Inpria is a Corvallis, Oregon-based startup that is developing advanced EUV photoresists – key patterning materials – for the semiconductor industry. Here at Inpria, we have been involved with a range of activities that align with the subjects outlined in this request for public comments. Additionally, prior to joining Inpria's team, I spent nine years – from 1999 to 2008 – at Menlo Ventures, an early-stage venture capital firm based in Menlo Park, California. At that time, Menlo Ventures was still actively investing in the semiconductor industry. As a Senior Associate at Menlo Ventures I was responsible for sourcing, researching and supporting our investments in the semiconductor industry. Drawing from my experiences over the past 20+ years at these two organizations I would like to share the following comments for your consideration.

In regards to: *(i) Critical and essential goods and materials underlying the semiconductor manufacturing and advanced packaging supply chain;*

INPRIA CORPORATION is a venture backed startup that has developed and commercialized advanced EUV photoresists for the semiconductor industry. Photoresists are one of the critical and essential materials underlying the semiconductor manufacturing process and supply chain. These photoreactive materials convert a light-based pattern into a physical template (much like a stencil) to control where various materials – such as metals, insulator and semiconductor materials - are applied onto the silicon wafer to build up a semiconductor stack. Each generation of photoresists is tuned to the specific wavelength of light and process flow conductions. Thus, new photoresist materials are required for new processing technologies, a chip manufacturer would not simply use a single photoresist to pattern every layer of a chip from top to bottom. Thus, a given semiconductor stack could have some layers using the most advanced patterning technologies and photoresists, and other less detailed layers that use much older generations of patterning technologies and photoresist. Similarly, when determining their manufacturing flows, chip manufacturers will select which photoresist materials to use on a per layer basis.

For the past 25 years or so, the $3 billion worldwide photoresist industry has been increasingly dominated by large non-US companies using organic (carbon-based) compounds. In stark contrast to this, Inpria, based in Corvallis, Oregon, is a venture-backed startup with about 50 employees. Inpria is developing and manufacturing a new class of photoresist materials, metal oxide-based materials, that are purpose-built for the world's most advanced commercially available patterning technology, Extreme Ultraviolet Lithography (EUV lithography). EUV lithography uses 13.5 nanometer light for patterning compared to the 193 nanometer light that is used in the prior generation of semiconductor patterning. EUV lithography as an industry market is incredibly concentrated. There is only one company in the world, ASML in the Netherlands, that manufactures the exposure tools. While EUV patterning is cost competitive at scale, the start-up costs are very high – a single EUV exposure tool costs over $100M. At these prices only the largest semiconductor manufacturers can afford to buy these tools and build the infrastructure that is required to use the tools. Today the world's largest semiconductor manufacturers (Intel, Samsung, TSMC, SK hynix, and Micron Technologies) are now all in various stages of adopting and using EUV lithography for their most advanced manufacturing processes. Inpria has received strong industry support. Currently, four of these manufacturers – Intel, Samsung, TSMC, and SK hynix – as well as two international photoresist manufacturers – JSR and TOK – are investors in Inpria.

Inpria is the only US-based photoresist manufacturer – of any size – that currently has commercially available advanced EUV photoresists available. Due to the high cost of EUV tools none of the EUV photoresist manufacturers can afford to buy their own EUV exposure tools to assist with product development and testing. Thus, everyone – from large materials suppliers to startups like Inpria – has to go to one of the world's few EUV shared user facility to do this work. Ironically, this has leveled the playing field since every company, no matter how large or small, has to rent time at a one of the world's few EUV shared user facilities. When we started our EUV development work there were two facilities that we considered as development partners: the now defunct SEMATECH (Albany, New York) and IMEC (Leuven, Belgium). These two facilities employed very different engagement models when we were selecting our development partner. SEMATECH's business model at that time required a significant upfront membership fee in order to do even the most preliminary of work. These membership fees were cost prohibitive for a startup of our size and level of funding at that time. In comparison, IMEC proactively approached us with creative ways to engage in zero dollar (free to Inpria) Joint Development Projects (JDP) and we continued working under this arrangement for a full four years before we executed our first paid JDP with IMEC. Since 2014 we have maintained a team of assignees who work onsite at IMEC and perform critical work to test and analyze our products on these tools.

From a supply chain perspective, our materials are based on tin oxide materials. Tin was specifically chosen for its superior ability to absorb EUV photons. The tin that we use in our materials is mined overseas and thus access to this raw metal is critical to our manufacturing and future development work.

In regards to*: (iii) the availability of the key skill sets and personnel necessary to sustain a competitive U.S. semiconductor ecosystem, including the domestic education and manufacturing workforce skills needed for semiconductor manufacturing; the skills gaps therein, and any opportunities to meet future workforce needs;*

The photoresist industry and EUV supply chain are predominantly located overseas which means that when we are looking to hire individuals with EUV industry experience and customer perspectives, it is likely that those candidates will be located overseas as well. As a small company (with less than 50 employees here in the US) we have already sponsored and successfully secured green card applications for two of our US-based employees. In both cases, these employees were actually foreign nationals who had come to the US for graduate school and during their graduate studies had developed specialized expertise that was critical to our work. We had also tried to sponsor these employees for H1B visas, but had far better luck with the green card process (National Importance Waiver) than the H1B lottery.

However, there have been other cases when we have been simply unable to hire uniquely qualified candidates because of immigration constraints and/or the associated process delays. This has been especially a concern on the customer-facing side (sales, business development and customer support) since the individuals who are often best positioned to play these roles are already to working at or close to these companies in Asia and thus unlikely to be already authorized to work in the United States.

While it was not a consideration when we started, an unexpected and significant benefit of our engagement with IMEC in Belgium has been the fact that the Belgian immigration system is more flexible than the system here in the US. Thus, it has been much easier for us to hire, secure work permits, and relocate expats to work there on assignment at IMEC. Since hiring our first Belgium-based employee in 2014 over 60% of our Belgium-based employees have been citizens of countries other than Belgium and nearly 50% have been citizens of non-EU countries. This includes three members of our US team who have spent time working there on assignment. There have already been several situations in which we have hired overseas employees and moved them to Belgium – even though our strong preference would have been to have them here in the US – because of the long lead time and uncertainty involved with current US immigration policies. As a result of the above factors, even though we are still a small company due to the nature of our industry and work we have had to support immigration activities and expertise that would normally be associated with a much larger company.

In regards to*: (v) the resilience and capacity of the semiconductor supply chain to support national and economic security and emergency preparedness, including:*

c. location of key manufacturing and production assets, and risks posed by these assets' physical location;

Our customers want us to move our photoresist manufacturing closer to their semiconductor chip manufacturing facilities which are predominantly located in Asia (and more specifically in Taiwan and South Korea). These customers are regularly asking us to establish a local presence. This close proximity has come to be expected as it is something that their other and much larger supply chain partners all provide.

f. need for research and development capacity to sustain leadership in the development of goods and materials critical or essential to semiconductor manufacturing;

One of the key issues facing semiconductor research and development activities within the startup community is access to adequate and appropriate funding sources. The traditional domestic funding sources (US-based venture capital investment firms) have largely been replaced by overseas strategic investors. Over the past 20 years, US venture capital has shifted farther and farther away from investing in early stage hardware technologies which take longer and more money to provide financial returns than the very popular and plentiful online software services and apps investments that exist today. Many of the firms that used to invest heavily in semiconductor companies have completely stopped making those investments, and the General Partners who used to sponsor these investments have long since retired. This has left a new generation of investors who have no experience with or patience for the longer industry development timelines. Furthermore, in the public markets, the high-priced valuations, IPOs and acquisitions given to software-based apps and services companies have generously rewarded the venture capital industry and further discouraged them from investing in many hardware-based and infrastructure markets.

Thankfully for early stage semiconductor companies, over the past 20 years strategic investors (corporate investors) in the semiconductor industry have shifted their focus to include earlier and earlier investments. As industry players they have the advantage of having much better visibility into the industry needs for and the significance of these future and emerging products. Since all of their investments must align strategically with their business needs and priorities, they can often afford to be far more patient than the average traditional venture capital firm. In the early 2000's when it was still common for mainstream venture capital firms to invest in semiconductor technologies, the normal funding path for a company such as Inpria would have been to secure early funding from several early stage venture capital firms and then in a much later stage round to bring in one or maybe two strategic investors. In Inpria's case, our first two rounds of equity funding were exclusively led by and had participation from strategic investors (one semiconductor equipment company and two semiconductor manufacturers). It was only after these three strategic investors had invested nearly $9 million that we received our first investment from a financial venture capital firm (OREGON VENTURE FIRM.) Today after five founds of venture capital financing (totaling $75M), our investor syndicate is still dominated by strategic investors. Our investor syndicate includes four semiconductor manufacturers, two photoresist manufacturers, one semiconductor equipment manufacturer, one industrial chemicals manufacturer, and two small financial venture firms. Since so much of the semiconductor industry is headquartered outside of the United States, it should be no surprise that many of our investors are international. In fact, six of our ten institutional (not individual angel investors) investors are based outside of the United States.

Even though we are now manufacturing and shipping our advanced EUV photoresists for revenue, we find that we are still facing a concentrated group of potential investors, most of whom are based outside of the US. As an EUV photoresist manufacturer, Inpria is subject to US Export Control Regulations under CCL 3C002.a and 3E001. Due to export control restrictions, we have declined multiple potential investment and partnership offers from companies that are based in mainland China, a country where semiconductor technology investments are still valued and celebrated in the investment community.

Our most recent round of financing (Q1 2020) was led and sufficiently comprised by international investors so that we were subject to CFIUS approval. We initially submitted a mandatory Declaration, but since the legislation was so new, we, like many other early submissions, learned that CFIUS could not make a determination within the Declaration timeline and thus we then had to then go through the full Notice process.

These two CFIUS review process delayed our ability to close this round by about a year. Fortunately, none of our investors bowed out due to the process delays but it was a legitimate concern of ours throughout this process. The delays did impact our ability to commence investment-associated Joint Development Projects with several investors and the legal expenses from the CFIUS process were large and vastly exceeded the legal fees we had budgeted for an investment round of this size.

Thinking ahead to the future, it is quite possible that the best follow-on investor and acquisition prospects for our company (in terms of both industry alignment and exit opportunities) could be overseas companies. If the US is committed to sustaining and/or expanding our R&D leadership in the semiconductor industry, it will be critical to understand and address the domestic funding and exit opportunities for startups in the semiconductor industry.

In regards to*: (vi) Potential impact of the failure to sustain or develop elements of the semiconductor supply chain in the United States on other key downstream capabilities, including but not limited to food resources, energy grids, public utilities, information communications technology (ICT), aerospace applications, artificial intelligence applications, 5G infrastructure, quantum computing, supercomputer development, and election security. Also, the potential impact of purchases of semi-conductor finished products by downstream customers, including volume and price, product generation and alternate inputs.*

EUV lithography is extremely power intensive. Proximity to a power generation source is a key driver in the location of these fab facilities. Access to water for cooling is also significant. For any US-based semiconductor manufacturing facilities employing EUV lithography at scale, the local energy grid and water system would need to be upgraded so that it is more resilient and more robust.

In regards to*: (vii) Policy recommendations or suggested executive, legislative, regulatory changes, or actions to ensure a resilient supply chain for semiconductors (e.g., reshoring, nearshoring, or developing domestic suppliers, cooperation with allies to identify or develop alternative supply chains, building redundancy into supply chains, ways to address risks due to vulnerabilities in digital products or climate change).*

At least until there are more early stage venture capital firms investing in semiconductor technologies again, I would recommend expanding matching fund programs like the SBIR Phase 2B program. This early funding can support new innovations long enough to get to the stage when they become ready for today's strategic investors. Inpria went through two families of SBIR grants with the NSF. Our SBIR grant funding supported our early development for the first 2 years of development and the Phase 2B $500k match opportunity helped us attract and negotiate the terms of our first investor.

As mentioned earlier, we also recommend that the CFIUS process be revised and optimized for small early stage companies. We were fortunate that our investors were very patient with this process, but that was not a foregone conclusion. From when we started our initial preparations to when we received final approval, we spent about a year on the CFIUS process and the legal fees were extremely expensive for a company our size.

Finally, as mentioned earlier, we encourage that you look for ways to support and encourage more private investment in semiconductor technologies. It would be great to see the venture capital community re-engage in the work of funding the semiconductor sector.

Thank you for this opportunity to provide some comments and perspective.

Best regards,

Ann M. Carney Nelson

Ann M. Carney Nelson

Chief Operating Officer

Inpria Corporation

Corvallis, Oregon